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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application Of:	)
ANTHONY J. ANDREWS	)
Application No.: 10/788,893	)
Filed: 02/27/2004	)
Group Art Unit:	)
Examiner:	)
LOUDSPEAKER ARRAY	)

TRANSMISSION OF PRIORITY DOCUMENT

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Sir:

Enclosed is a certified copy of the priority document identified in the formal papers of this application as filed.

The claim for priority made in the formal papers is reiterated.

Acknowledgement of the receipt of this certified copy in the next Patent Office correspondence is respectfully requested.

Respectfully submitted,

ANDRUS, SCEALES, STARKE & SAWALL, LLP

Joseph J. Jochman

Joseph J. Jochman
Reg. No. 25,058

Andrus, Sceales, Starke & Sawall, LLP
100 East Wisconsin Avenue, St. 1100
Milwaukee, WI 53202
(414) 271-7590
Attorney Docket No: 248-00290

INVESTOR IN PEOPLE

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1. Your reference	JSR.P52619GB
2. Patent application number *(The Patent Office will fill in this part)*	0306415.1
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Anthony John Andrews Funktion One Research Hoyle Farm Dorking Surrey, RH5 4PS
Patents ADP number *(if you know it)*	6193718002
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom
4. Title of the invention	"Loudspeaker Array"
5. Name of your agent *(if you have one)*	Marks & Clerk
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	4220 Nash Court Oxford Business Park South Oxford OX4 2RU United Kingdom
Patents ADP number *(if you know it)*	7271125001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	No

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Continuation sheets of this form	
Description	8
Claim *(s)*	3
Abstract	1
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Priority documents	
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~~Statement of inventorship and right~~ to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature | Date
Marks & Clerk | 20 March 2003

12. Name and daytime telephone number of person to contact in the United Kingdom

John S. Robinson
(01865) 397900

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DUPLICATE

LOUDSPEAKER ARRAY

The present invention relates to a loudspeaker array and to a loudspeaker system comprising a plurality of such arrays. Such an array or system may be used in a sound reinforcement system or "PA" (public address) system to provide sound reinforcement in an enclosed or "open air" auditorium or arena of relatively large size.

A known type of sound reinforcement system makes use of "line sources" of loudspeakers. Each loudspeaker comprises an electro-acoustic driver housed in some form of enclosure with the diaphragm of the driver radiating from a front of the enclosure directly into the environment. The individual loudspeakers are arranged as vertical one-dimensional straight line arrays. Such arrays radiate sound throughout a very large angle in a horizontal plane. A typical line source radiates sound relatively evenly throughout more than 90° and up to 130° in a horizontal plane.

If more than one such line source is needed in order to provide sufficient sound pressure levels at a venue, several line sources may be used but must be spaced apart by a sufficiently large distance so as to avoid undesirable interference with each other. Mutual spacings of greater than about 20 feet (about 3.5 metres) are required so that undesirable interference effects are reduced to an acceptably low level, for example below normal audibility to listeners. Because of the wide dispersion pattern, it is impossible to avoid destructive interference when a listener is located away from a centre vertical plane between a pair of line sources. It is therefore impossible to achieve an increase in sound pressure level simply by adding another line source adjacent an existing line source.

In applications where the locations of the loudspeakers of a sound reinforcement system are limited, a system based on conventional line sources may be difficult, inconvenient, or impossible to provide. For example, in applications where sound reinforcement is required throughout a relatively large area but sound reinforcement loudspeakers are restricted in location to a much smaller area, conventional line source techniques are not capable of providing an acceptable sound pressure level throughout

the area. An example of such a situation is in a rectangular arena, comprising audience accommodation around the sides of a sports area, where the sound reinforcement loudspeakers may only by located at the middle of a shorter side of the rectangular arena.

According to a first aspect of the invention, there is provided a loudspeaker array as defined in the appended claim 1.

According to a second aspect of the invention, there is provided a loudspeaker system as defined in the appended claim 18.

Embodiments of the invention are defined in the other appended claims.

Each loudspeaker has a sound propagation axis which is generally the central axis of the three dimensional dispersion pattern and sometimes, but not always, corresponds to the direction of maximum sound output. For example, in the case of cone diaphragm drivers driven by a voice coil in a magnetic gap having an acoustic channel or "waveguide" arrangement extending forwardly of the cone diaphragm with at least vertical and horizontal planes of symmetry, the sound propagation axis is defined by the line at the intersection of the planes of symmetry.

In the case of a generally vertically extending line source, for off-axis listening in the horizontal plane, the sound pressure level falls as the angle relative to the sound propagation axis increases. The angle of a dispersion pattern is the angle between directions at which the sound pressure level has fallen to a predetermined level relative to a reference level. Typically, the sound pressure level on the sound propagation axis is taken as the reference level and the dispersion pattern angle is measured between the directions at which sound pressure level has dropped by three decibels (-3dB) relative to the reference level. This corresponds to half the reference loudness in audible terms.

Time-alignment refers to the effective point source constituted by each loudspeaker. In the case of cone diaphragm loudspeakers driven at or near the centre of

the cone by a voice coil former carrying a voice coil within a magnetic gap, the diaphragm does not move as a rigid unit because of its flexibility. The effective point source of such a driver is therefore in the region where the former is fixed to the diaphragm since this is effectively the first point from which sound will be radiated. For time-alignment in the case of a one dimensional straight line array of loudspeakers, all of the effective point sources of the loudspeakers are required to lie on a straight line, which is generally perpendicular to the sound propagation axes where the axes are parallel to each other. For a one dimensional curved array in the form of an arc of a circle, time-alignment is achieved by disposing the loudspeakers such that the sound propagation axes intersect each other at the centre of the arc with the effective point sources all being spaced by the same radius from the centre.

Although time-alignment may be achieved by the actual locations of the loudspeakers, time-alignment may be achieved by a combination of physical location and electronic signal processing. Thus, signal delays may be provided in a digital crossover processing system for dividing the frequency spectrum supplied to the loudspeakers to compensate for or to permit actual locations of the effective point sources being different from the relative locations which would provide time-alignment without such electronic adjustment.

The or each line source is "one dimensional" in the conventional sense of having no width and depth, but is not limited to being arranged in a straight line. In a typical arrangement, the effective point sources of the loudspeakers, which may be the actual effective point sources or equivalent effective point sources allowing for any relative time delay in the signal supplied to the loudspeaker, are arranged in a vertical plane with the one dimension and the sound propagation axes all being contained in that plane. The line source may, for example, be arranged as a one dimensional straight line array or as a one dimensional circular arc array. In embodiments where there are two or more line sources, the effective sound sources may, for example, be disposed on cylindrical or spherical surfaces with the sound propagation axes being directed radially outwardly.

The dispersion pattern perpendicular to the one dimension (generally but not necessary horizontal or nearly horizontal in use) is such as to permit line sources to be located close together without undesirable mutual interference. Thus, an array may be provided for covering a relatively large area from one relatively small region, for example at the edge of the area to be covered. By clustering loudspeaker arrays together, the sound dispersion provided by a system can be designed or arranged to provide a desired sound pressure level at substantially any point within a region to be covered. Thus, a very compact loudspeaker system can be provided for achieving a desired sound pressure level at any point in "line-of-sight" within an arena or other venue.

The invention will be further described, by way of example, with reference to the accompany drawings, in which:

Figure 1 is a front view of a loudspeaker system constituting an embodiment of the invention;

Figure 2 is a side view of the system of Figure 1;

Figure 3 is a plan view of the system of Figure 1;

Figure 4 is a front partly diagrammatic view of a first loudspeaker array forming part of the system of Figure 1;

Figure 5 is a side view of the array of Figure 4;

Figure 6 is a plan view of the array of Figure 4;

Figure 7 is a front view of another array forming part of the system of Figure 1;

Figure 8 is a side view of the array of Figure 7;

Figure 9 is a plan view of the array of Figure 7;

Figure 10 is a view from the front and to the side of the array of Figure 7;

Figure 11 is a front view of a full-range loudspeaker system including the system of Figure 1;

Figure 12 is a plan view of the full-range system of Figure 11; and

Figure 13 is a view from the front of, to the side of and below the full-range system of Figure 11.

Like reference numerals refer to like parts throughout the drawings.

The loudspeaker system shown in Figures 1 to 2 comprises five loudspeaker arrays which are symmetrical about a central vertical plane and which cover a frequency range from about 300Hz to about 17KHz. Each of the arrays comprises mid range loudspeakers covering the frequency range from about 300Hz to about 7KHz and high frequency loudspeakers covering the frequency range from about 5.7KHz to about 17KHz. The loudspeaker system is intended, for example, for use in an arena of generally rectangular shape with a rectangular sports area and audience accommodation along two long sides and one short side of the rectangle. The system is intended for mounting generally at the middle of the other short side above audience level. The loudspeaker system occupies a very small region compared with the size of the arena and provides a desired and a sufficiently uniform sound pressure level throughout the whole of the audience accommodation.

The loudspeaker system comprises a first loudspeaker array 1 for directing sound to an opposite short side of the arena, a pair of symmetrically arranged second arrays 2 and 3 for providing coverage of much of the long sides, and a symmetrical pair of third arrays 4 and 5 for providing cover of the nearer ends of the long sides.

The loudspeaker array 1 is shown in Figures 4 to 6 and comprises two pairs of line sources in the form of one-dimensional arrays of loudspeakers. The first pair comprises line sources 10 and 11 of mid-range loudspeakers whereas the second pair comprises line sources 12 and 13 of high frequency loudspeakers ("tweeters").

Each of the mid-range loudspeakers comprises an electromagnetic 8 inch (20cm) diameter cone diaphragm driver disposed at the rear of and directing sound into a "waveguide" for controlling, among other things, the sound dispersion pattern of the loudspeaker. In the example illustrated, the horizontal dispersion angle is about 20 degrees and the vertical dispersion angle is relatively small, for example less than 10 degrees. Each of the loudspeakers such as 14 produces a substantially plane wave and the dispersion patterns are such that the sound pressure level declines rapidly for angles greater than half the dispersion angle away from the sound propagation axis of the loudspeaker. The driver and the waveguide are both symmetrical about vertical and substantially horizontal planes and the intersection of these planes defines the sound propagation axis, about which the dispersion patterns vertically and horizontally are substantially symmetrical.

Each of the loudspeakers of the line sources 12 and 13 comprises a one inch (2.5cm) diameter high frequency compression driver such as 15 directing sound into a horn such as 16. The drivers 15 and the horns 16 are also symmetrical about vertical and substantially horizontal planes, whose intersections define the sound propagation axes of the high frequency loudspeakers.

Each of the loudspeakers 14 may be of the type disclosed in US Patent Application No. 08/199455.

The loudspeakers of the array 1 are arranged such that there effective point sources are located on the surface of a sphere with the sound propagation axes being directed radially outwardly from the centre of the sphere. The line sources 10 and 11 are angled apart such that the vertical planes passing through the sound propagation axes of these line sources intersect at about 20 degrees. For many applications, it is

appropriate for the angle in the horizontal plane between line sources to be substantially equal to the sound dispersion angle of the loudspeakers making up the sources. Such arrays thus produce substantially coherent wave fronts with well-defined and controllable directionality.

Although the effective point sources in the illustrated embodiment are disposed on the surface of a sphere, for some applications, they may be disposed on the surface of an ellipsoid or on a surface having a first radius of curvature in the vertical plane and a second radius of curvature in the horizontal plane (such as a torus). Also, each of the line sources 10 to 12 is curved in the vertical plane by providing an angle greater than zero degrees and generally less than 10 degrees in the vertical plane between the sound propagation axes of adjacent pairs of loudspeakers. The curvature may be varied and may be made infinite to provide a straight line array depending on the specific requirement, such as the distance to the region to be covered by the line source and the size of that region.

Disposing line sources of this type near to each other allows a system to be built and tuned to provide any desired pattern of sound pressure level within line-of-sight of the system. Interference between line sources is reduced or eliminated or acts constructively to allow line sources to be disposed adjacent each other.

Figures 7 to 9 illustrate the loudspeaker array 3 of Figure 1 from four different views. The array 2 is the mirror image of the array 3.

The array 3 differs from the arrays 11 and 13 in that the mid-range array comprises four loudspeakers instead of six loudspeakers, the high range array comprises ten loudspeakers instead of fifteen, and the radius of curvature of the array 3 in the vertical plane is smaller so as to give a larger vertical dispersion angle for the array. The radius of curvature of the array 3 and its azimuth relative to the array 1 are determined by the "footprint" which the array 3 is required to cover and the number of loudspeakers is determined by distance to the footprint so as to provide a sufficiently uniform sound level at the audience area from all parts of the loudspeaker system.

The line sources 4 and 5 differ from the line sources 2 and 3 in that each mid-range array comprises two loudspeakers and each high frequency array comprises five loudspeakers. Again, the radius of curvature in the vertical plane and the azimuth are determined according to the required footprint, which is relatively near to the loudspeaker system so that fewer loudspeakers are required to provide the desired sound pressure level.

The arrays 1 to 5 cover the audible frequency range above about 300Hz. In order to provide a full-range system with a frequency range extending down to bass frequencies, these arrays may be augmented by further loudspeakers as illustrated in Figures 11 to 13. The lower-mid frequency range is handled by three curved line arrays of loudspeakers as illustrated at 20 whereas the low bass frequency range is handled by stacks of bass loudspeakers 21 and 22. Each of the loudspeakers 20 may be of the type disclosed, for example, in EP 1069803 and each of the bass loudspeakers may be of the type disclosed in EP 1164814. Although the dispersion patterns of the loudspeakers of the line arrays 20 are such that the same principles may be used in these line sources as in the line sources 1 to 5, the bass loudspeaker provide wider dispersion patterns so that the stacks 21 and 22 operate more like conventional line sources but with restricted frequency ranges.

CLAIMS:

1. A loudspeaker array comprising at least one line source, the or each line source comprising a one dimensional array of substantially time-aligned loudspeakers, each of which has a dispersion pattern subtending an angle θ of less than 50° in a plane which is perpendicular to the one dimension at the loudspeaker.

2. An array as claimed in claim 1, in which θ is substantially equal to 20°.

3. An array as claimed in claim 1 or 2, in which each of the loudspeakers is arranged to produce a substantially plane wave throughout the frequency range of the loudspeaker.

4. A array as claimed in any one of the preceding claims, in which the or each line source comprises at least three loudspeakers.

5. An array as claimed in any one of the preceding claims, in which each of the loudspeakers has a sound propagation axis and the propagation axes of the loudspeakers of the or each line source are in a plane containing the one dimension.

6. An array as claimed in claim 5, in which the propagation axes of adjacent pairs of loudspeakers in the or each line source subtend an angle of between 0° and 10°.

7. An array as claimed in any one of the preceding claims, in which the loudspeakers of the or each line source are disposed in a straight line.

8. An array as claimed in any one of claims 1 to 6, in which the loudspeakers of the or each line source are disposed on a circular arc.

9. An array as claimed in claim 8, in which the loudspeakers of the or each line source are arranged to radiate away from a centre of curvature of the arc.

10. An array as claimed in any one of the preceding claims, in which the loudspeaker of the or each line source are of the same type.

11. An array as claimed in any one of the preceding claims, having a frequency range from substantially 300Hz to substantially 7KHz.

12. An array as claimed in any one of the preceding claims, comprising a plurality of line sources disposed laterally adjacent each other.

13. An array as claimed in claim 12, with an angle substantially equal to θ between planes containing sound propagation axes of the or each adjacent pair of line sources.

14. An array as claimed in claim 12 or 13, in which the loudspeakers of all of the line sources are substantially time-aligned.

15. An array as claimed in any one of claims 12 to 14, in which the loudspeakers of the line sources are of the same type.

16. An array as claimed in any one of claims 12 to 14, in which the line sources comprise first and second sets, the loudspeakers of the or each line source of the first set having a first frequency range and the loudspeakers of the or each line source of the second set having a second frequency range different from the first frequency range.

17. An array as claimed in claim 16, in which the first frequency range is substantially contiguous with or overlaps the second frequency range.

18. A loudspeaker system comprising a plurality of loudspeaker arrays, each as claimed in any one of the preceding claims.

19. A system as claimed in claim 18 when dependent on claim 8, in which the radius of the circular arc of the or each line source of a first of the loudspeaker arrays is

different from the radius of the circular arc of the or each line source of a second of the loudspeaker arrays.

ABSTRACT

LOUDSPEAKER ARRAY

(Figure 1)

A loudspeaker array comprises line sources (1-5). Each line source comprises a one dimensional array of loudspeakers. The loudspeakers have horizontal dispersion angles less than 45 degrees. The loudspeakers of each line source are time-aligned.

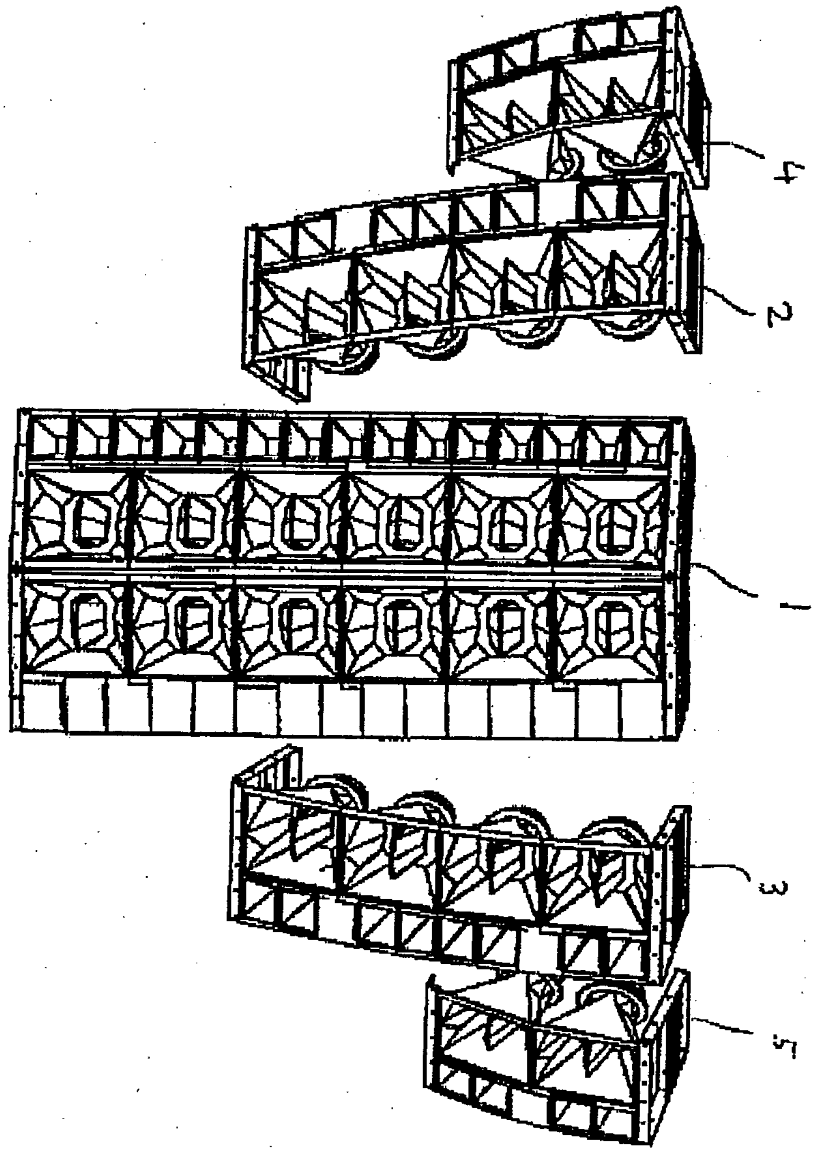


Fig 1

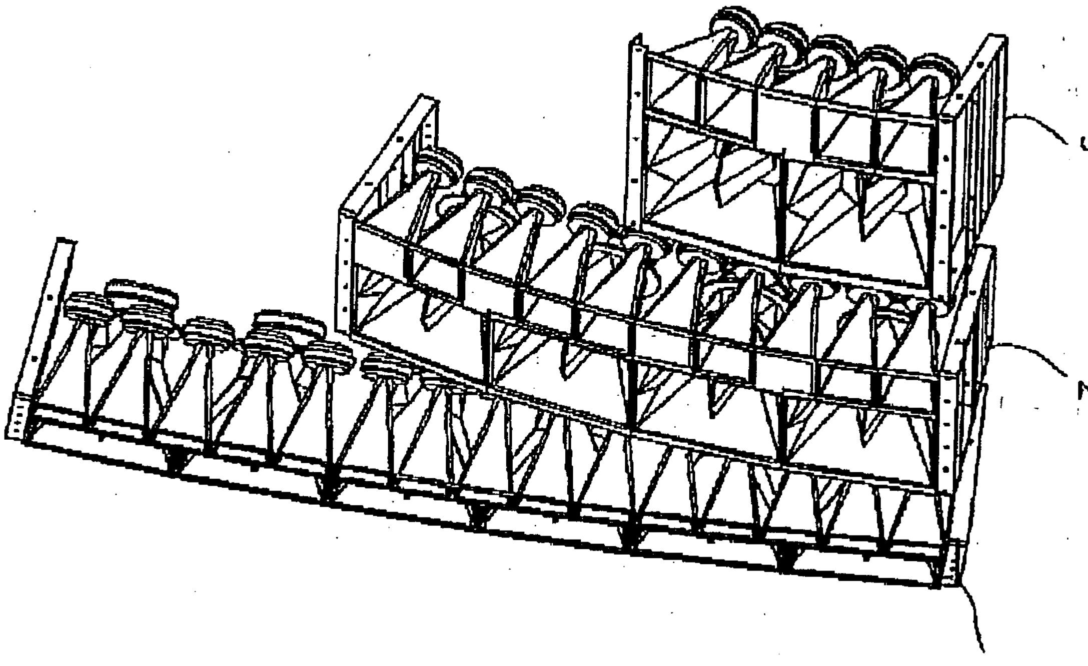


Fig 2

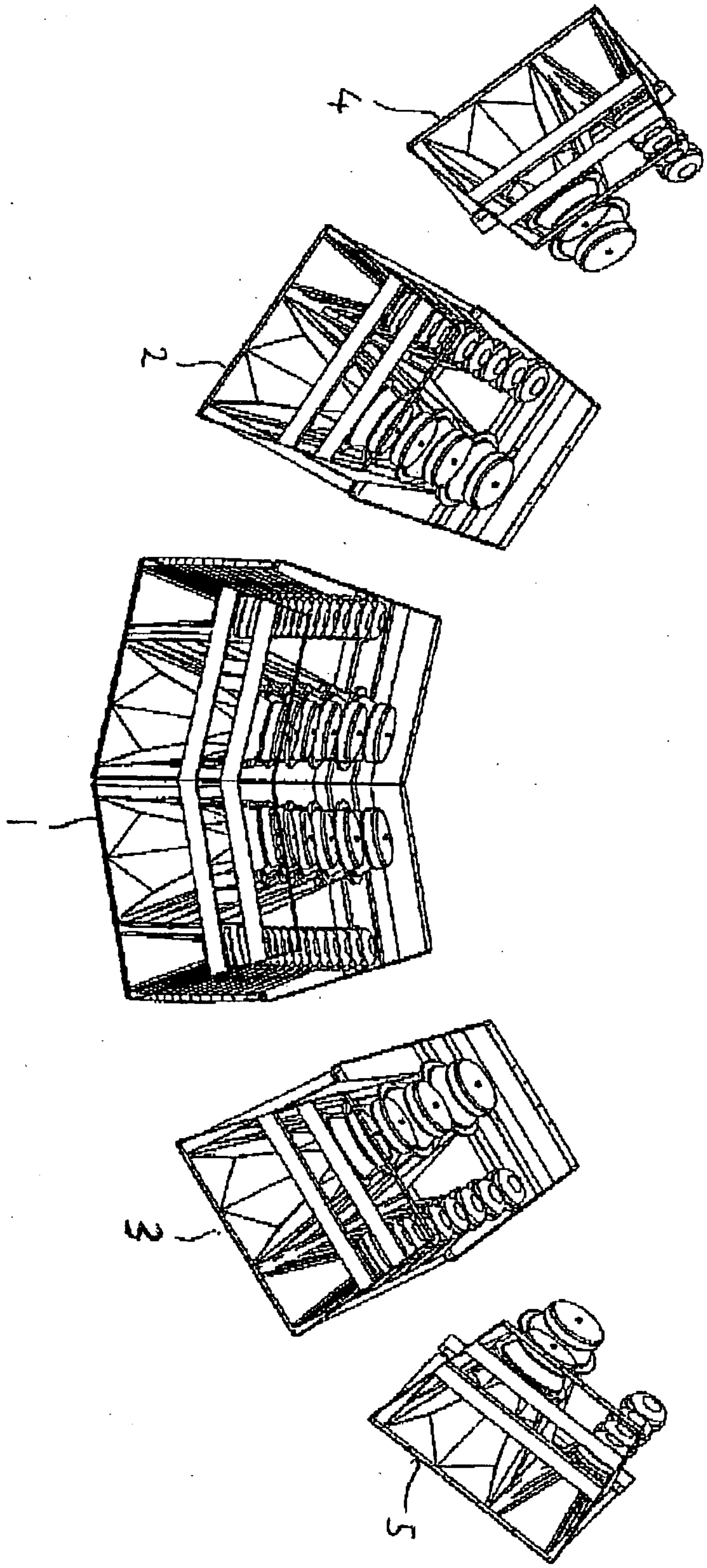
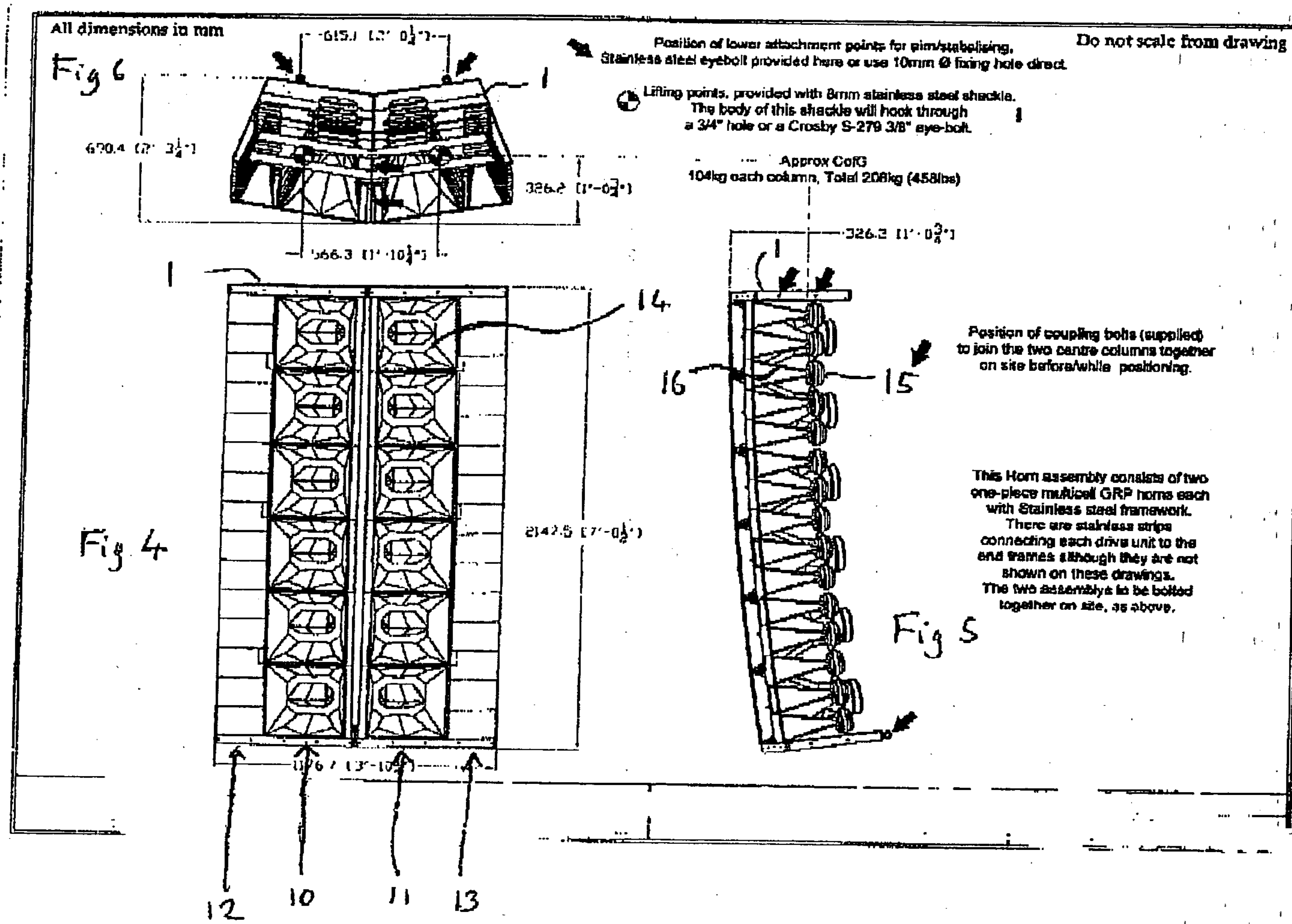


Fig 3


All dimensions in mm
Do not scale from drawing
Fig 6
Position of lower attachment points for aim/stabilising. Stainless steel eyebolt provided here or use 10mm Ø fixing hole direct.
Lifting points, provided with 8mm stainless steel shackle. The body of this shackle will hook through a 3/4" hole or a Crosby S-279 3/8" eye-bolt.
Approx CofG
104kg each column, Total 208kg (458lbs)
Position of coupling bolts (supplied) to join the two centre columns together on site before/while positioning.
This Horn assembly consists of two one-piece multicell GRP horns each with Stainless steel framework. There are stainless strips connecting each drive unit to the end frames although they are not shown on these drawings. The two assemblys to be bolted together on site, as above.
Fig 4
Fig 5
1
14
15
16
12
10
11
13

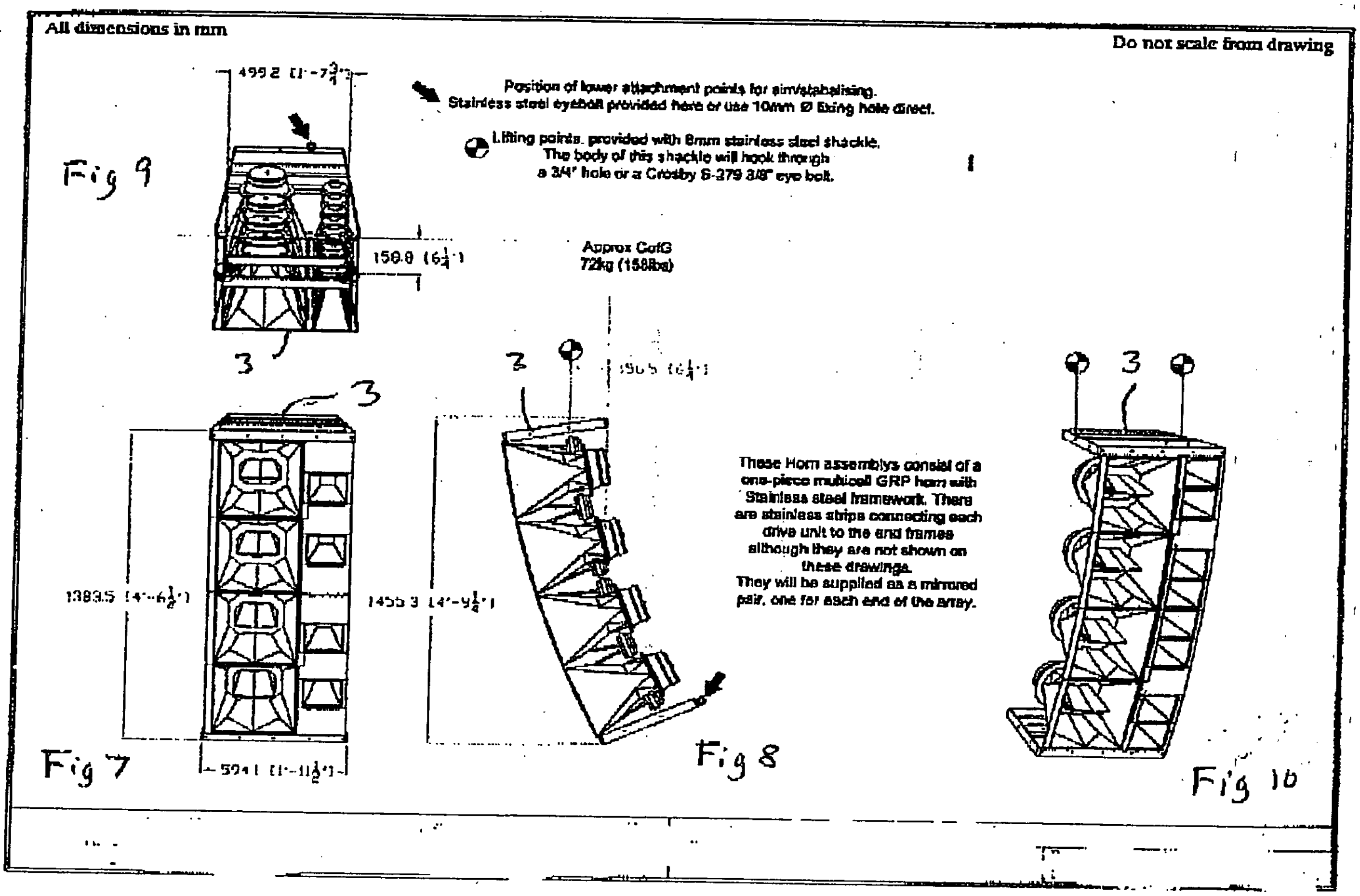


Fig 9

Fig 7

Fig 8

Fig 10

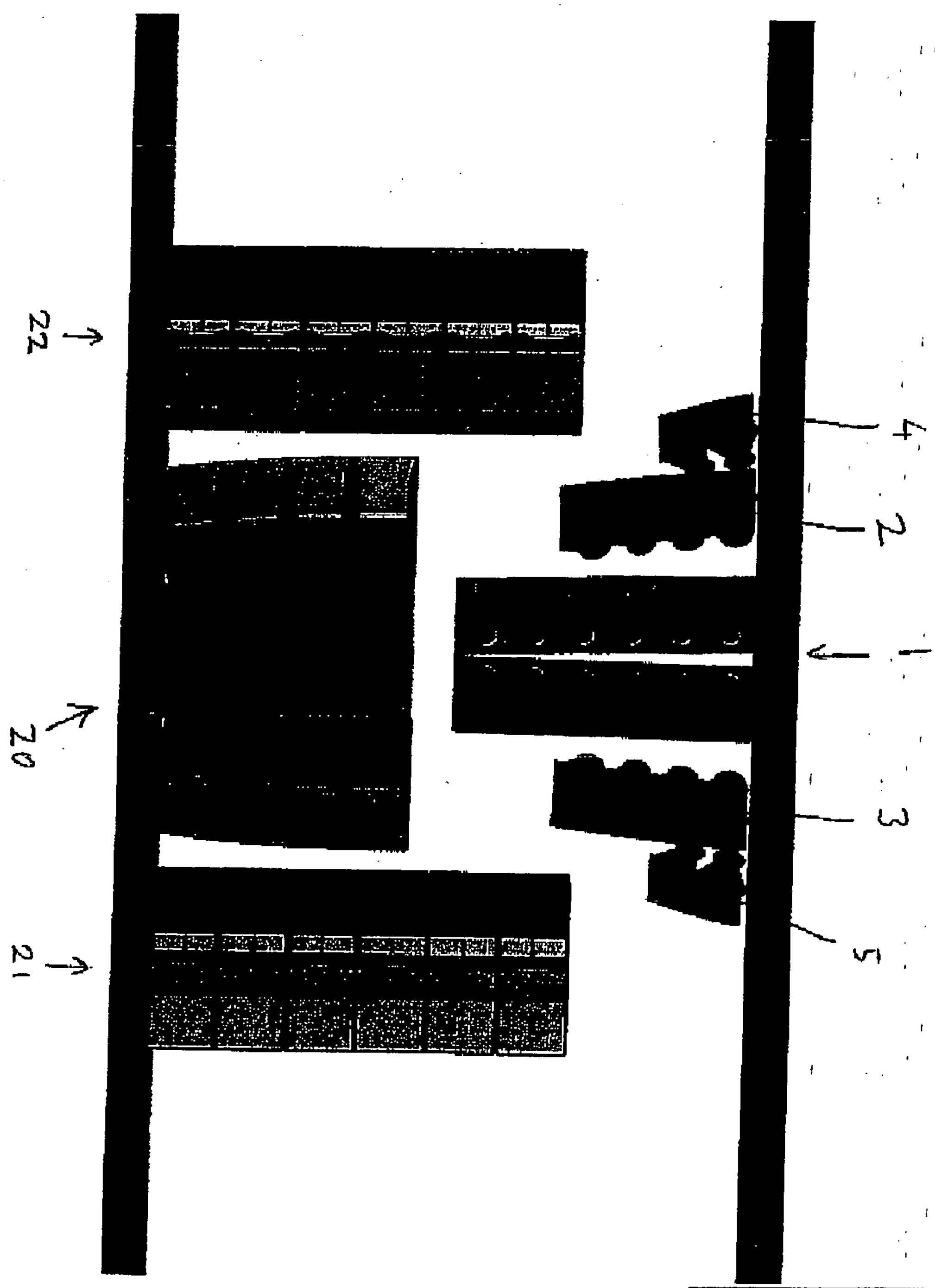


Fig 11

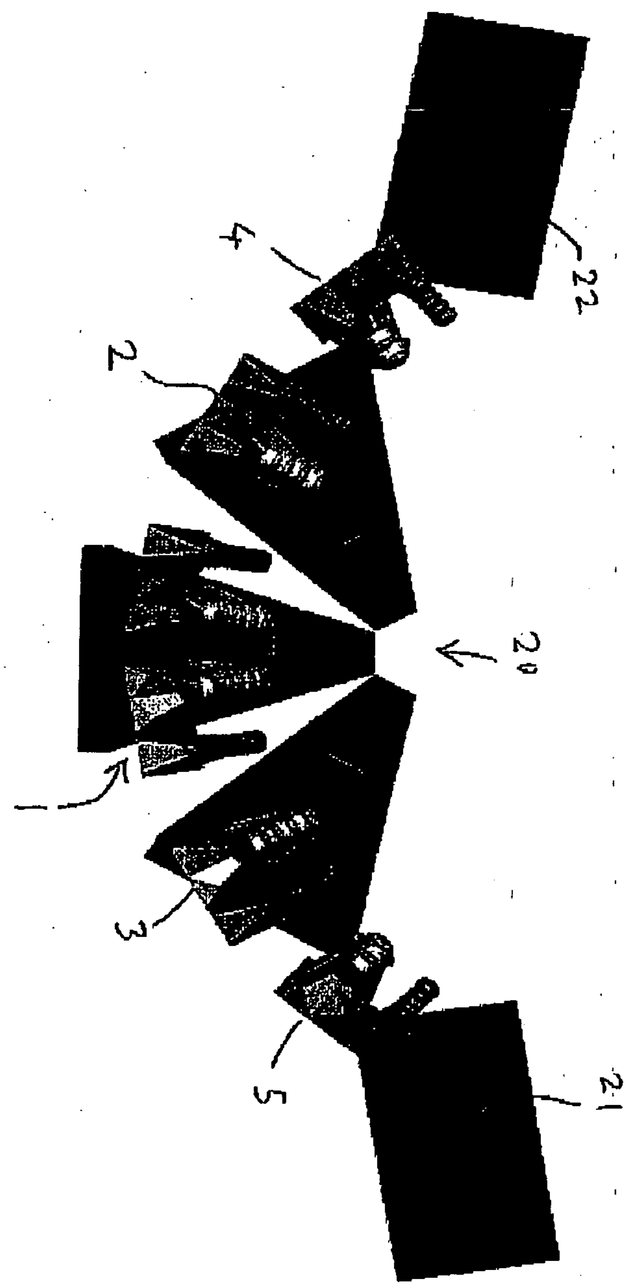


Fig 12

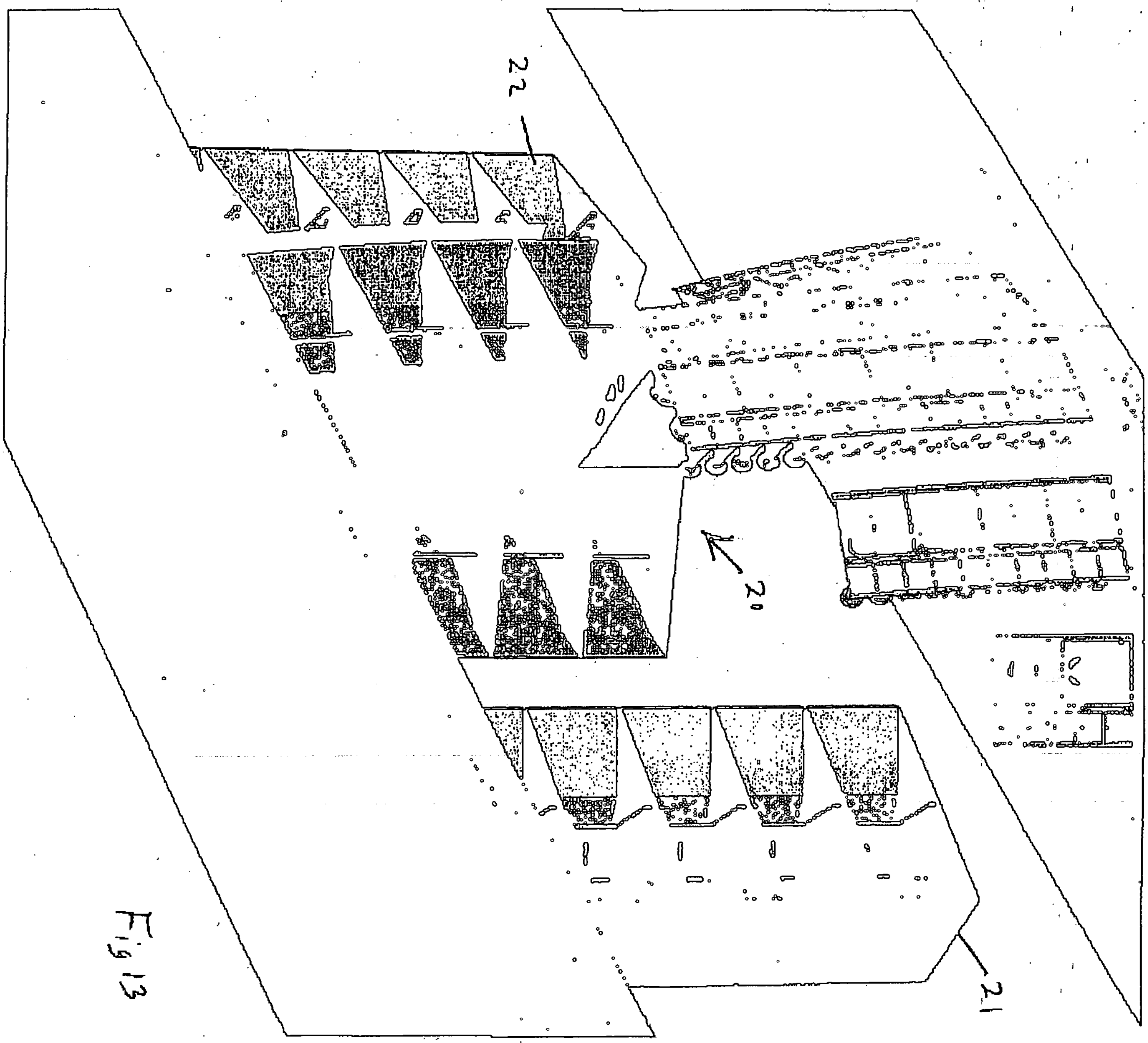


Fig 13